In the matter of
United States Patent Application No. 09/317,056
in the name of NEC Corporation

DECLARATION

I, Masao SEKIGUCHI, c/o YAMASHITA & ASSOCIATES of Toranomon 40th MT Bldg., 13-1, Toranomon 5-chome, Minato-ku, Tokyo, Japan, do solemnly and sincerely declare that I well understand the Japanese language and the English language and that the attached English translation of a certified copy of Japanese Patent Application No. 154130/1998 is a true, correct and faithful translation to the best of my knowledge and belief from the Japanese language into the English language.

Dated this 23th day of August, 2005

Masao Sekiguchi

Masao SEKIGUCHI

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【List of Attached Documents】

【Name of Document】 Specification 1

【Name of Document】 Drawings 1

【Name of Document】 Abstract 1

【Need or not of Proof】 need

【Name of the Document】 Specification

【Title of the Invention】 METHOD FOR DRIVING SOLID-STATE IMAGE PICKUP DEVICE

【Claims】

【Claim 1】 A method for driving a solid-state image pickup device which stores, into a plurality of photo-electric conversion units, signal charges corresponding to an incident light during a prescribed time period, excludes surplus charges with a first electric potential barrier by a blooming control structure which is comprised in said photo-electric conversion unit, reads out, after cutting off the incident light by a light cut-off means, the signal charges with grouping said photo-electric conversion units into a prescribed number of regions, and outputs image signal from all of the photo-electric conversion units by plurally repeating the read-out procedures, said method which comprises the steps of:

cutting off the incident light by said light cut-off means;

setting a second electric potential barrier higher than the first electric potential barrier; and

starting reading out the signal charges.

【Claim 2】 A method for driving a solid-state image pickup device which stores, into a plurality of photo-electric conversion units, signal charges corresponding to an incident light during a prescribed time period, excludes surplus charges with a first electric potential barrier based on a first substrate voltage by a vertical overflow drain (OFD) structure of a blooming control structure which is comprised in said photo-electric

conversion unit, reads out, after cutting off said incident light by a light cut-off means, the signal charges with grouping said photo-electric conversion units into a prescribed number of regions, and outputs image signal from all of the photo-electric conversion units by plurally repeating the read-out procedures, said method which comprises the steps of:

cutting off the incident light by said light cut-off means;

setting a second electric potential barrier higher than the first electric potential barrier, the second electric potential barrier being set on the basis of a second substrate voltage; and

starting reading out the signal charges.

【Claim 3】 A method for driving a solid-state image pickup device which stores, into a plurality of photo-electric conversion units, signal charges corresponding to an incident light during a prescribed time period, excludes surplus charges with a first electric potential barrier based on a first gate voltage by a horizontal overflow drain (OFD) structure of a blooming control structure which is comprised in said photo-electric conversion unit, reads out, after cutting off the incident light by a light cut-off means, the signal charges with grouping said photo-electric conversion units into a prescribed number of regions, and outputs image signal from all of the photo-electric conversion units by plurally repeating the read-out procedures, said method which comprises the steps of:

cutting off the incident light by said light cut-off means;

setting a second electric potential barrier higher than the first electric potential barrier, the second electric potential barrier being set on the basis of a second gate voltage; and starting reading out the signal charges.

【Detailed Description of the Invention】

【0001】

【Technical Field to which the Invention Belongs】

The present invention relates to a method for driving solid-state image pickup devices.

【0002】

【Prior Art】

When solid-state image pickup devices developed for a video tape recorder (VTR) integrated with a camera are diverted to solid-state image pickup devices which are used as image input devices for electronic still cameras or personal computers, a signal processing for converting the pixel number and the scanning format is required, because display format for monitors of personal computers (progressive format) is different from display format for the standard TV receivers (interlace format).

【0003】

Therefore, the progressive format type solid-state image pickup devices which can read out all the pixels without the signal processing for converting the pixel number and the scanning format are employed for the input devices for the electronic still cameras or personal computers.

【0004】

Nevertheless, the interlace format type solid-state image

pickup devices are used often, because they can be manufactured by fewer steps, their image cells can be highly integrated, and they can be used also for a video tape recorder (VTR) integrated with a camera, as described in TAKEMURA Hiroo "CCD Camera Technique" Radio Gijutu Co., Showa 61 (1986) November 3, First Edition, pp 23-30 and pp46-50.

【0005】

Figure 11 is a plan view of a conventional interlace type solid-state image pickup device with a vertical charge transfer unit wherein signal charges are transferred by double layered electrodes and four phased pulses.

【0006】

The conventional interlace type solid-state image pickup device as shown in Figure 11 comprises photo-electric conversion unit 101, vertical charge transfer unit 102 which signal charges are transferred by double layered electrodes and four phased pulses, horizontal charge transfer unit 103, and output circuit 104. In addition, one step vertical charge transfer unit is connected with two photo-electric conversion units which are lined in vertical direction, or in other words, 1/2 step vertical charge transfer unit is connected with one photo-electric conversion unit.

【0007】

Figure 12 is a plan view of cells of the conventional solid-state image pickup device. The solid-state image pickup device comprises photoelectric conversion unit 101, vertical charge transfer unit 102, first charge transfer electrode 105, and second

charge transfer electrode 106.

【0008】

Figure 13 is a cross sectional view of the cells along the plane I-I' of Figure 12. The cells as shown in Figure 13 comprise N^- type semiconductor substrate 107, P^- type semiconductor substrate 108, N type semiconductor region 109, P^+ type semiconductor substrate 110, first charge transfer electrode 105 of first layer poly-silicon 111, second charge transfer electrode 106 of second layer poly-silicon 112, aluminum film 113 such as shading film, insulating film 114, and cover insulating film 115.

【0009】

The conventional interlace type solid-state image pickup device operates under the timing chart as shown in Figure 14.

【0010】

Firstly, in order to reset the unnecessary charges in photo-electric conversion unit at time t_1, a reverse bias voltage VHsub is applied to the N^- type semiconductor substrate 107 as shown in Figure 15. Hereupon, the unnecessary charges are swept out into the N^- type semiconductor substrate 107, because the N type semiconductor region 109 and the P^- type semiconductor region 108 which is located immediately below the N type semiconductor region 109 become complete depletion layer by the applied reverse bias voltage VHsub. The N type semiconductor region 109 constitutes the photo-electric conversion unit 101. Such a structure is generally called a vertical type over-flow drain (a vertical type OFD) structure as described in Journal of Television Society Vol.37, No.10 (1983) pp782 - 787.

【0011】

Next, a voltage VBsub is applied to N^- type semiconductor substrate 107 to start storing signal charges corresponding to the incident light in photo-electric conversion unit 101, while surplus charges which can not be stored in photo-electric conversion unit 101 are excluded into N^- type semiconductor substrate 107 by using vertical OFD structure. Such an exclusion of the surplus charges is called blooming control.

【0012】

Next, at time t_2 when a prescribed exposure time (t_1-t_2) passes, the incident light is cut off by a light cut-off means such as a mechanical shutter which is positioned in front of the solid-state image pickup device.

【0013】

Then, at time t_4, signal charges in odd photo-electric conversion units which are lined in a horizontal direction, for example, such as signal charges 11,12,13,31,32,33,51,52,53 are read out into the corresponding vertical charge transfer units 102. The read signal charges are transferred vertically line by line into horizontal charge transfer unit 103 through the vertical charge transfer units 102 and the transferred signal charges are transferred horizontally through the horizontal charge transfer unit 103 to output them from output circuit 104.

【0014】

Finally, at time t_5, signal charges in even photo-electric conversion units which are lined in a horizontal direction, for example, such as signal charges 21,22,23,41,42,43,61,62,63 are

read out into the corresponding vertical charge transfer units 102 and then outputted likewise as above mentioned. Thus, the signal charges from all of the pixels for one frame of display can be acquired, as described in TAKEMURA Hiroo "CCD Camera Technique" Radio Gijutu Co., pp 23-30, pp46-50.

【0015】

【Problems to be solved by the invention】

However, the above-mentioned conventional solid-state image pickup device has a disadvantage that saturation signal quantity decreases with increasing read-out cycles when after cutting off said incident light by a light cut-off means, the photo-electric conversion units are grouped into a prescribed number of regions, and signal charges are read out to vertical charge transfer unit by plural read-out procedures.

【0016】

Therefore, an object of the present invention is to provide a method, which improves the above-mentioned disadvantage that saturation signal quantity decreases with increasing read-out cycles, for driving solid-state image pickup devices.

【0017】

【Means for solving the Problem】

According to one aspect of the present invention, there is provided a method for driving a solid-state image pickup device which stores, into a plurality of photo-electric conversion units, signal charges corresponding to an incident light during a prescribed time period, excludes surplus charges with a first electric potential barrier by a blooming control structure which

is comprised in the photo-electric conversion unit, reads out, after cutting off the incident light by a light cut-off means, the signal charges with grouping the photo-electric conversion units into a prescribed number of regions, and outputs image signal from all of the photo-electric conversion units by plurally repeating the read-out procedures, the method which comprises the steps of cutting off the incident light by the light cut-off means; setting a second electric potential barrier higher than the first electric potential barrier; and starting reading out the signal charges.

【0018】

According to another aspect of the present invention, there is provided a method for driving a solid-state image pickup device which stores, into a plurality of photo-electric conversion units, signal charges corresponding to an incident light during a prescribed time period, excludes surplus charges with a first electric potential barrier based on a first substrate voltage by a vertical overflow drain (OFD) structure of a blooming control structure which is comprised in the photo-electric conversion unit, reads out, after cutting off the incident light by a light cut-off means, the signal charges with grouping the photo-electric conversion units into a prescribed number of regions, and outputs image signal from all of the photo-electric conversion units by plurally repeating the read-out procedures, the method which comprises the steps of cutting off the incident light by the light cut-off means; setting a second electric potential barrier higher than the first electric potential

barrier, the second electric potential barrier being set on the basis of a second substrate voltage; and starting reading out the signal charges.

【0019】

According to another aspect of the present invention, there is provided a method for driving a solid-state image pickup device which stores, into a plurality of photo-electric conversion units, signal charges corresponding to an incident light during a prescribed time period, excludes surplus charges with a first electric potential barrier based on a first gate voltage by a horizontal overflow drain (OFD) structure of a blooming control structure which is comprised in the photo-electric conversion unit, reads out, after cutting off the incident light by a light cut-off means, the signal charges with grouping the photo-electric conversion units into a prescribed number of regions, and outputs image signal from all of the photo-electric conversion units by plurally repeating the read-out procedures, the method which comprises the steps of cutting off the incident light by the light cut-off means; setting a second electric potential barrier higher than the first electric potential barrier, the second electric potential barrier being set on the basis of a second gate voltage; and starting reading out the signal charges.

【0020】

【Embodiments of the Invention】

The first embodiment of the present invention is explained, referring to the drawings.

【0021】

The operation of the first embodiment of the invention is explained, referring to the timing chart as shown in Figure 1, concerning the interlace type solid-state image pickup device with the vertical OFD structure for the blooming control structure which excludes surplus charges.

【0022】

Firstly, in order to reset the unnecessary charges in photo-electric conversion unit at time t_1, a reverse bias voltage VHsub is applied to N^- type semiconductor substrate 107 as shown in Figure 2. Hereupon, the unnecessary charges are swept out into N^- type semiconductor substrate 107, because N type semiconductor region 109 and P^- type semiconductor region 108 which is located immediately below the N type semiconductor region 109 become complete depletion layers by the applied reverse bias voltage VHsub. The N type semiconductor region 109 constitutes the photo-electric conversion unit 101.

【0023】

Next, a voltage VBsub is applied to N^- type semiconductor substrate 107 to start storing signal charges corresponding to the incident light in photo-electric conversion unit 101, while surplus charges which can not be stored in photo-electric conversion unit 101 are excluded into N^- type semiconductor substrate 107 by using vertical OFD structure for the blooming control.

【0024】

Next, at time t_2 when a prescribed exposure time (t_1-t_2) passes,

the incident light is cut off by a light cut-off means such as a mechanical shutter which is positioned in front of the solid-state image pickup device.

【0025】

Then, at time t_3, a voltage VLsub is applied to N^- type semiconductor substrate 107 to raise up by $\Delta\phi$ the potential barrier of the vertical OFD structure for the signal charges, whereby the leakage of the signal charges due to the self-induced drift, or the thermal diffusion is suppressed. The $\Delta\phi$ may be preferably about 0.7 V for such a suppression.

【0026】

Then, at time t_4, signal charges in odd photo-electric conversion units which are lined in a horizontal direction, for example, such as signal charges 11,12,13,31,32,33,51,52,53 are read out into the corresponding vertical charge transfer units 102. The read signal charges are transferred vertically line by line into horizontal charge transfer unit 103 through the vertical charge transfer units 102 and the transferred signal charges are transferred horizontally through the horizontal charge transfer unit 103 to output them from output circuit 104.

【0027】

Finally, at time t_5, signal charges in even photo-electric conversion units which are lined in a horizontal direction, for example, such as signal charges 21,22,23,41,42,43,61,62,63 are read out into the corresponding vertical charge transfer units 102 and then outputted likewise as above mentioned. Thus, the signal charges from all of the pixels for one frame of display

can be acquired.

【0028】

In the first embodiment of the present invention, after cutting off the incident light by a light cut-off means, the substrate voltage is set to VLsub and applied to raise up the potential barrier for signal charges so that the leakage of the signal charges due to the self-induced drift or the thermal diffusion is suppressed, and then the signal charges are read out from the desired regions of the photo-electric conversion unit into the vertical charge transfer unit. Consequently, the disadvantage that the saturation signal quantity decreases depending upon the storage time is overcome by the first embodiment of the present invention.

【0029】

Next, the second embodiment of the present invention is explained, referring to the drawings.

【0030】

Figure 4 is a conceptual plan view of an X-Y addressed solid-state image pickup device.

【0031】

The X-Y addressed solid-state image pickup device as shown in Figure 4 comprises photo-electric conversion unit 201, vertical shift register 202, horizontal shift register 203, load transistor 204, address line 205, and signal line 206.

【0032】

Figure 5(a) is a cross sectional view of photo-electric conversion unit 201. The photo-electric conversion unit 201

comprises P^- type semiconductor substrate 221, P^- type semiconductor region 222, P^+ type semiconductor region 223, N type semiconductor region 224, N^+ type semiconductor region 225, reset transistor 211, driving transistor 212 for a source follower circuit, and selection transistor X 213.

【0033】

The operation of the second embodiment of the present invention is explained, referring to the timing chart as shown in Figure 3, concerning the X-Y addressed solid-state image pickup device with the horizontal OFD structure for the blooming control structure.

【0034】

Firstly, in order to reset the unnecessary charges in photo-electric conversion unit at time t_1, a voltage VHg is applied to reset transistor 211 as shown in Figure 5(c). Hereupon, the electric potential of reset transistor becomes deep. Further, the electric potential of N type semiconductor region 224 which constitutes photo-electric conversion unit 201 set to be equal to the voltage VDD of a voltage source.

【0035】

Next, a voltage VBg is applied to reset transistor 211 in order to start storing signal charges corresponding to the incident light in photo-electric conversion unit 201, while surplus charges which can not be stored in photo-electric conversion unit 201 are excluded into N^+ type semiconductor region 225 which the voltage VDD of a voltage source is applied, by using horizontal OFD structure for the blooming control.

【0036】

Next, at time t_2 when a prescribed exposure time (t_1-t_2) passes, the incident light is cut off by a light cut—off means such as a mechanical shutter which is positioned in front of the solid-state image pickup device.

【0037】

Then, at time t_3, a voltage VLg is applied to reset transistor 211 to raise up by $\Delta\phi$ the potential barrier of the horizontal OFD structure for the signal charges, whereby the leakage of the signal charges due to the self-induced drift, or the thermal diffusion is suppressed. The $\Delta\Phi$ may be preferably about 0.7 V for such a suppression.

【0038】

Then, at time t_4, signal charges are read out from odd photo-electric conversion units which are lined in a horizontal direction and outputted.

【0039】

Finally, at time t_5, signal charges are read out from even photo-electric conversion units which are lined in a horizontal direction and then outputted likewise as above mentioned. Thus, the signal charges from all of the pixels for one frame of display can be acquired.

【0040】

In the second embodiment of the present invention, after cutting off the incident light by a light cut-off means, the reset gate voltage is set to voltage VLg and applied to raise up the potential barrier for signal charges so that the leakage of the signal

charges due to the self-induced drift or the thermal diffusion is suppressed, then the signal charges are read out from the desired regions of the photo-electric conversion unit into the vertical charge transfer unit. Consequently, the disadvantage that the saturation signal quantity decreases depending upon the storage time is overcome by the second embodiment of the present invention.

【0041】

【Effect of the Invention】

As mentioned above, in the first embodiment of the present invention, after cutting off the incident light by a light cut-off means, the substrate voltage is set to VLsub and applied to raise up the potential barrier for signal charges so that the leakage of the signal charges due to the self-induced drift or the thermal diffusion is suppressed, and then the signal charges are read out from the desired regions of the photo-electric conversion unit into the vertical charge transfer unit. Consequently, the disadvantage that the saturation signal quantity decreases depending upon the storage time is overcome by the first embodiment of the present invention.

【0042】

In the second embodiment of the present invention, after cutting off the incident light by a light cut-off means, the reset gate voltage is set to voltage VLg and applied to raise up the potential barrier for signal charges so that the leakage of the signal charges due to the self-induced drift or the thermal diffusion is suppressed, then the signal charges are read out from the

desired regions of the photo-electric conversion unit into the vertical charge transfer unit. Consequently, the disadvantage that the saturation signal quantity decreases depending upon the storage time is overcome by the second embodiment of the present invention.

【0043】

It is clear that the present invention is not restricted to the above embodiments and each of the embodiments may be arbitrarily changed within the scope of the present invention.

【Brief explanation of the drawings】

【Figure 1】

Figure 1 is a timing chart for driving the solid-state image pickup device of a first embodiment of the present invention.

【Figure 2】

Figure 2 is a potential diagram of the photo-electric conversion unit with the vertical OFD (overflow drain) structure of the first embodiment of the present invention.

【Figure 3】

Figure 3 is a timing chart for driving the solid-state image pickup device of the second embodiment of the present invention.

【Figure 4】

Figure 4 is a conceptual plan view of the solid-state image pickup device of the second embodiment of the present invention.

【Figure 5】

Figure 5 is a potential diagram of the photo-electric conversion unit with the horizontal OFD (overflow drain) structure of the second embodiment of the present invention.

【Figure 6】

Figure 6 is a conceptual plan view of a conventional solid-state image pickup device.

【Figure 7】

Figure 7 is a conceptual plan view of a photo-electric conversion unit of the conventional solid-state image pickup device.

【Figure 8】

Figure 8 is a cross sectional view along I-I' plane of the photo-electric conversion unit of the conventional solid-state image pickup device.

【Figure 9】

Figure 9 is a timing chart for driving the conventional solid-state image pickup device.

【Figure 10】

Figure 10 is a potential diagram of the conventional photo-electric conversion unit with the vertical OFD (overflow drain) structure.

【Explanation of Signature】

101 photo-electric conversion unit

102 vertical charge transfer unit

103 horizontal charge transfer unit

104 output circuit

105 first charge transfer electrode

105 second charge transfer electrode

107 N^- type semiconductor substrate

108 P^+ type semiconductor substrate

109 N type semiconductor region

110 P^+ type semiconductor region

111 first poly-silicon

112 second poly-silicon

113 aluminum

114 insulating film

115 cover insulating film

201 photo-electric conversion unit

202 vertical shift register

203 horizontal shift resister

204 load transistor

205 address line

206 signal line

221 P^- type semiconductor substrate

222 P type semiconductor region

223 P^+ type semiconductor region

224 N type semiconductor region

225 N^+ type semiconductor region

211 reset transistor

212 driving transistor of source follower circuit

213 selection transistor

【Name of Document】 Abstract

【Abstract】

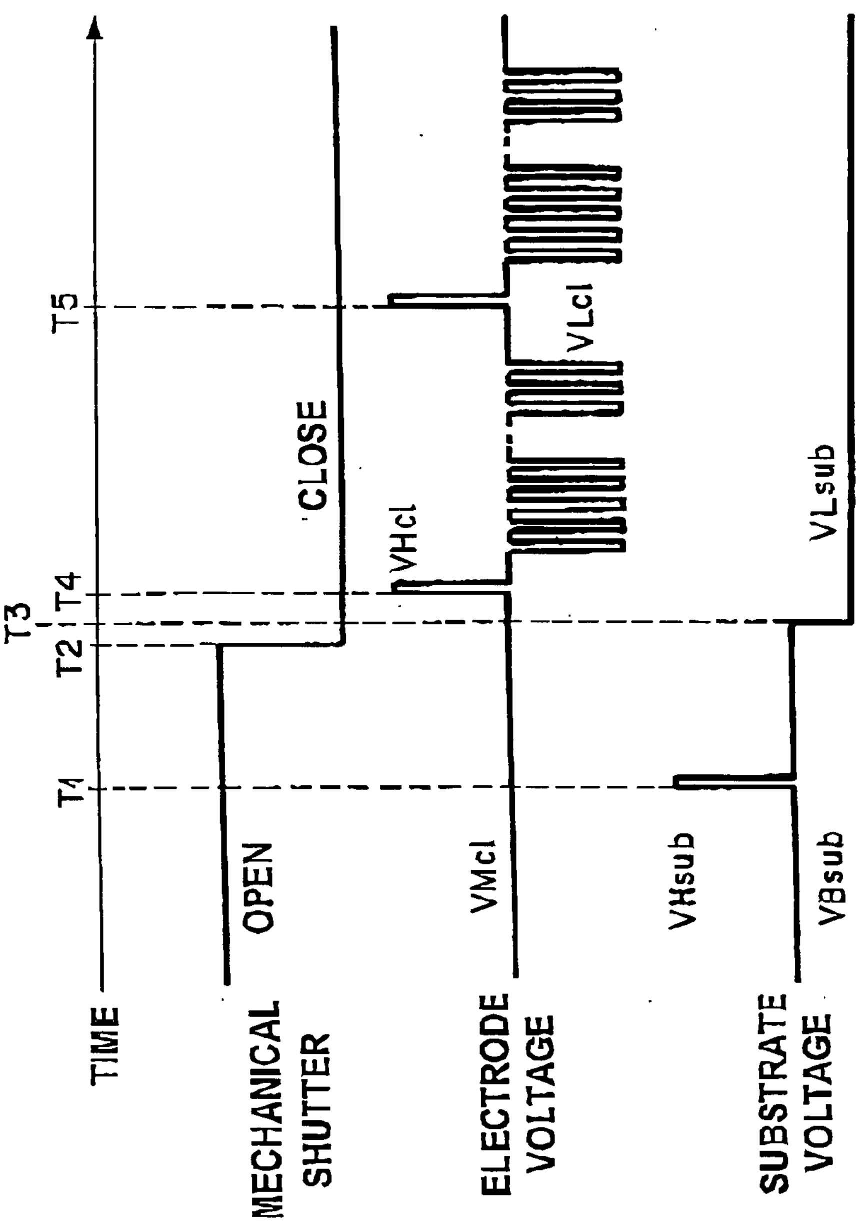
【Problem】 To overcome a disadvantage that the saturation signal quantity decreases depending upon the storage time in a photo-electric conversion unit of a solid-state image pickup device.

【Solving Means】 At time t_2 when a prescribed exposure time (t_1-t_2) passes, the incident light is cut off by a light cut off means such as a mechanical shutter which is positioned in front of the solid-state image pickup device. Then, at time t_3, a voltage VBsub is applied to N^- semiconductor substrate 107 to raise up the potential barrier of the vertical OFD structure for the signal charges, whereby the leakage of the signal charges due to the self-induced drift, or the thermal diffusion is suppressed. Then, at time t_4, signal charges in odd photo-electric conversion units which are lined in a horizontal direction are read out, and at time t_5, signal charges in even photo-electric conversion units which are lined in a horizontal direction are read out.

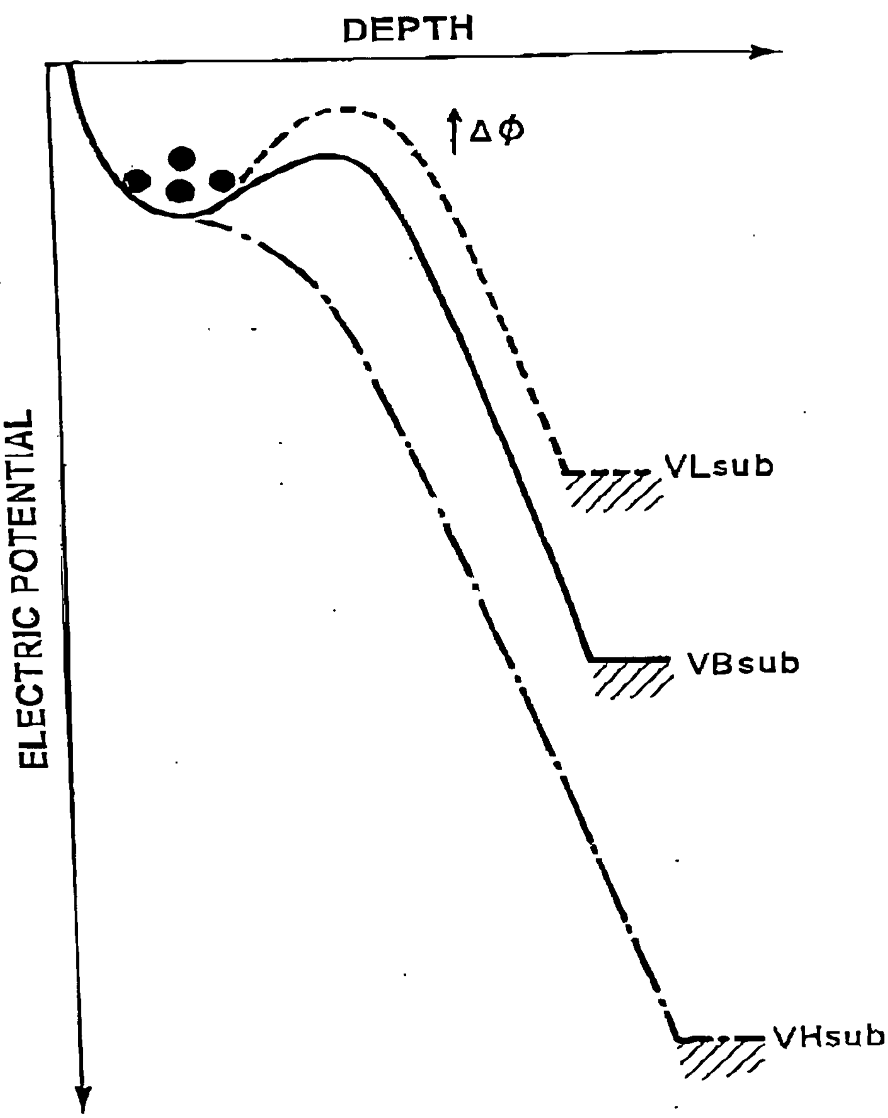
【Selected Figure】 Figure 1

【Document Name】 DRAWINGS

【Figure 1】



【Figure 2】



【Figure 3】

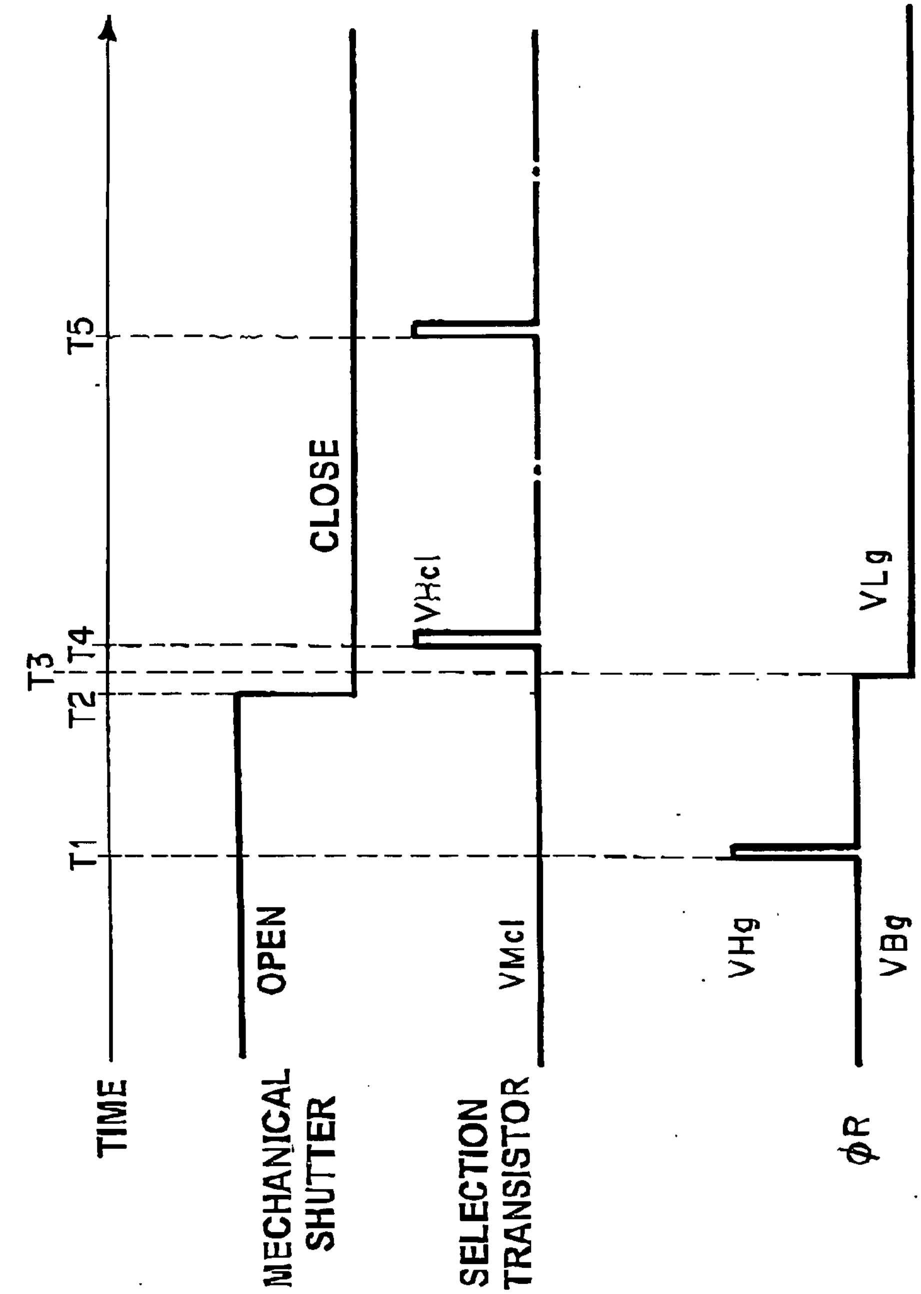
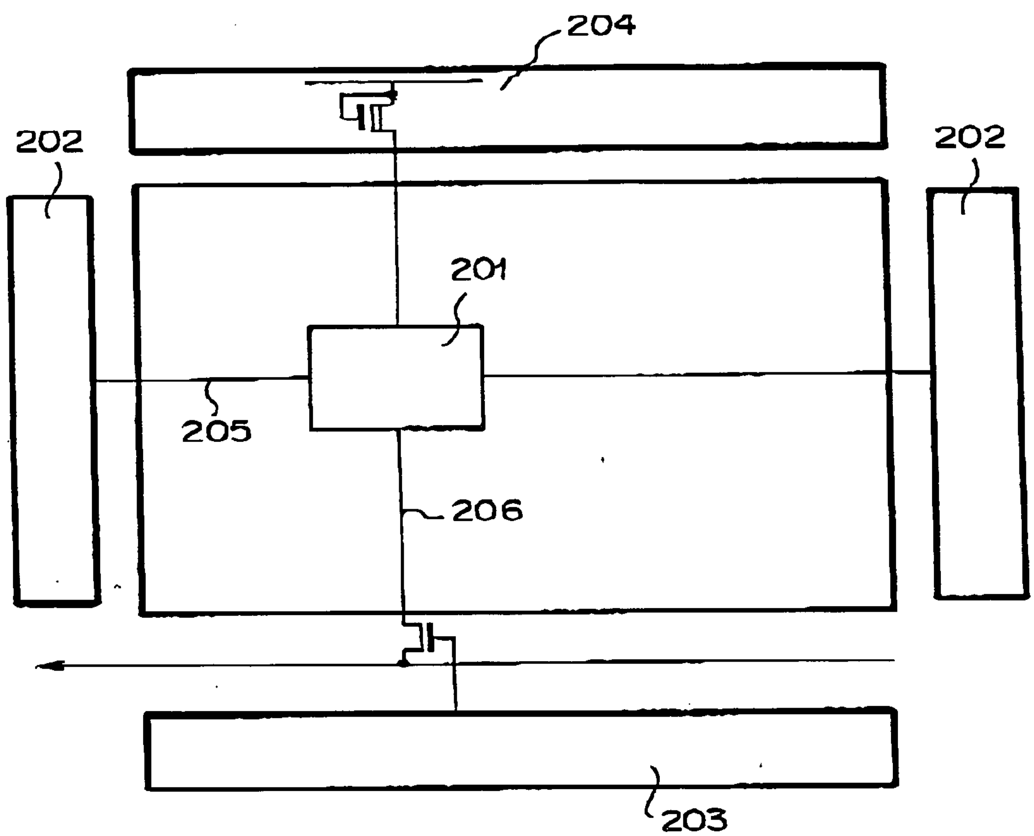
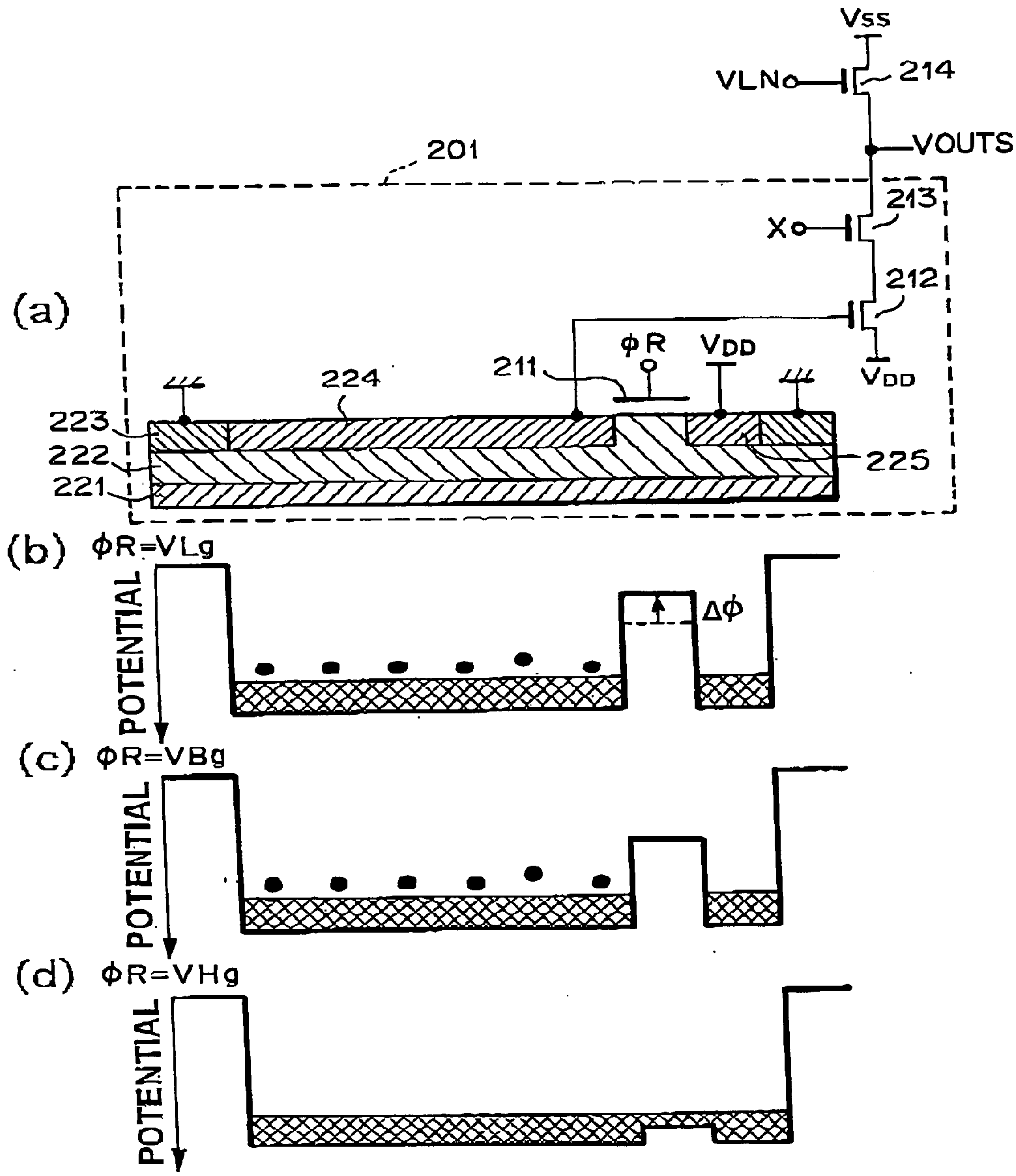


FIG. 3

【Figure 4】

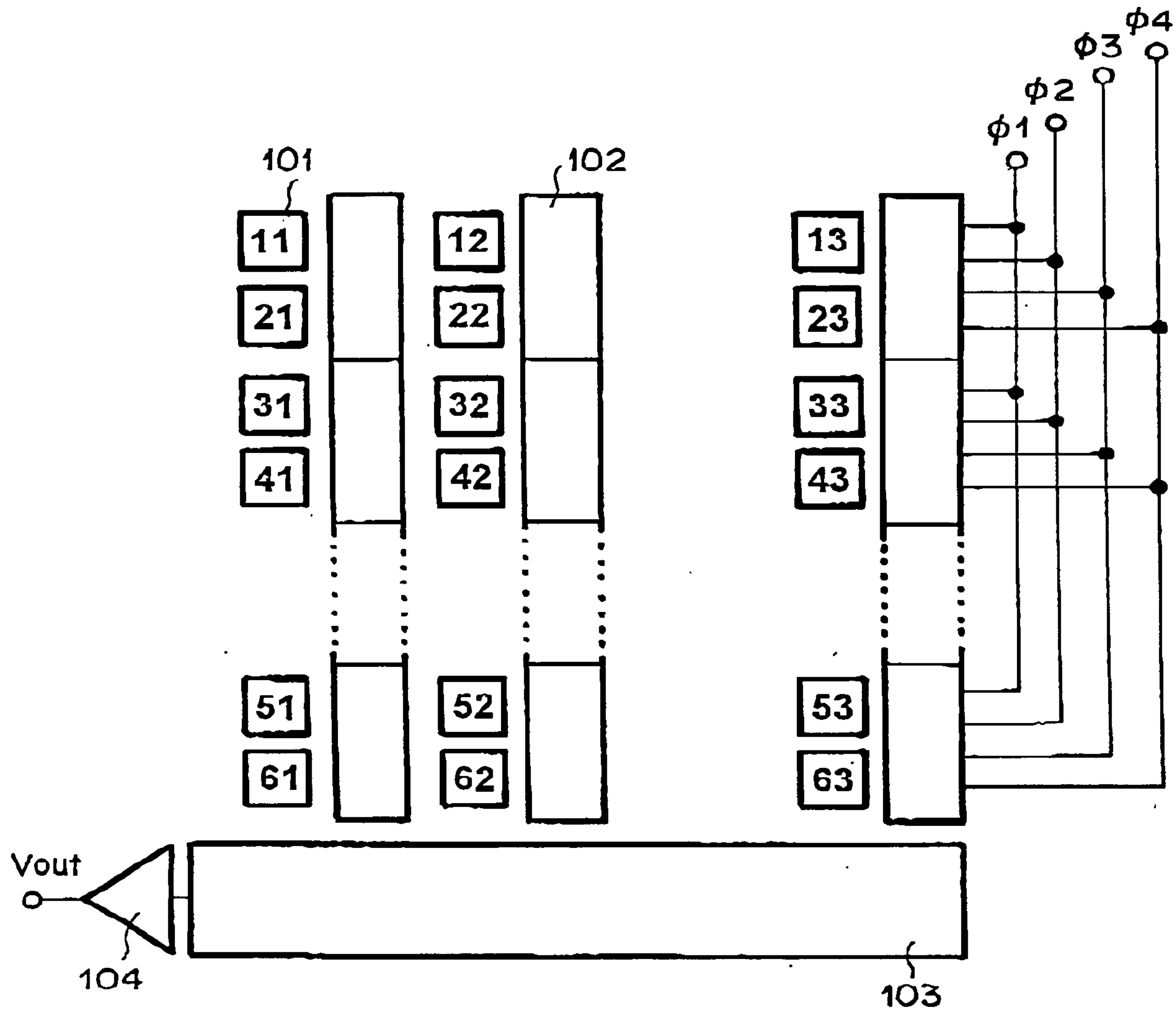


【Figure 5】



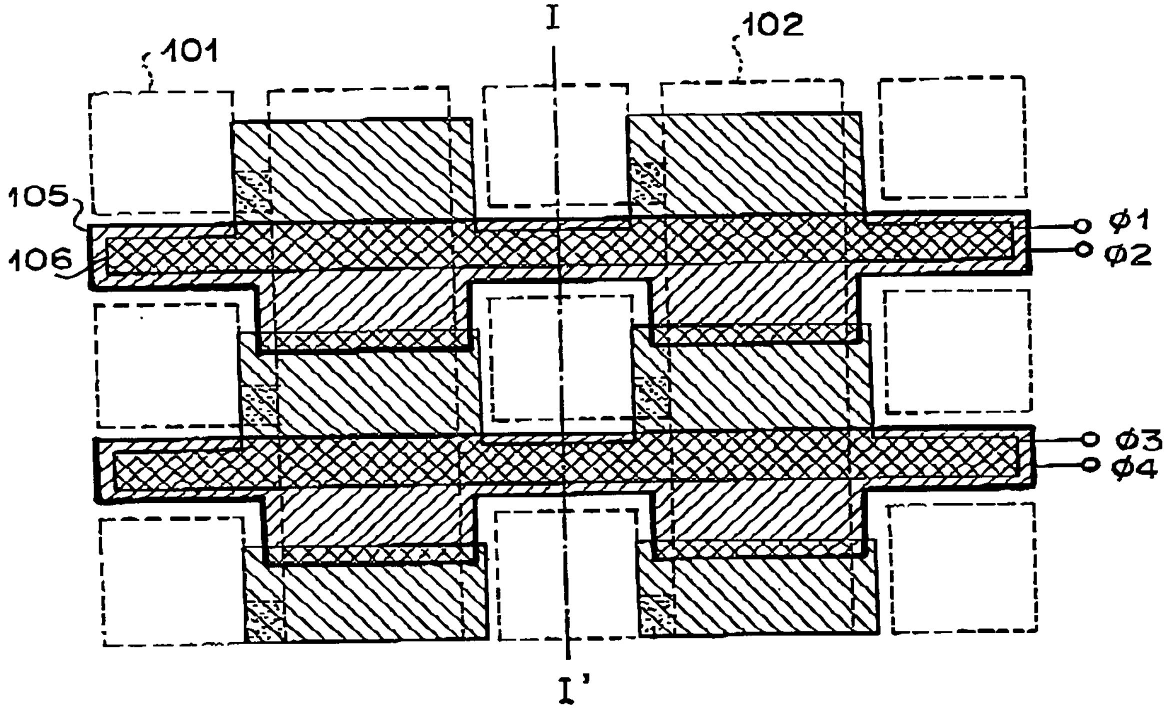
Vss
VLN
214
VOUTS
201
213
X
212
(a)
ΦR
VDD
VDD
211
224
223
222
221
225
(b) ΦR=VLg
POTENTIAL
ΔΦ
(c) ΦR=VBg
POTENTIAL
(d) ΦR=VHg
POTENTIAL

【Figure 6】

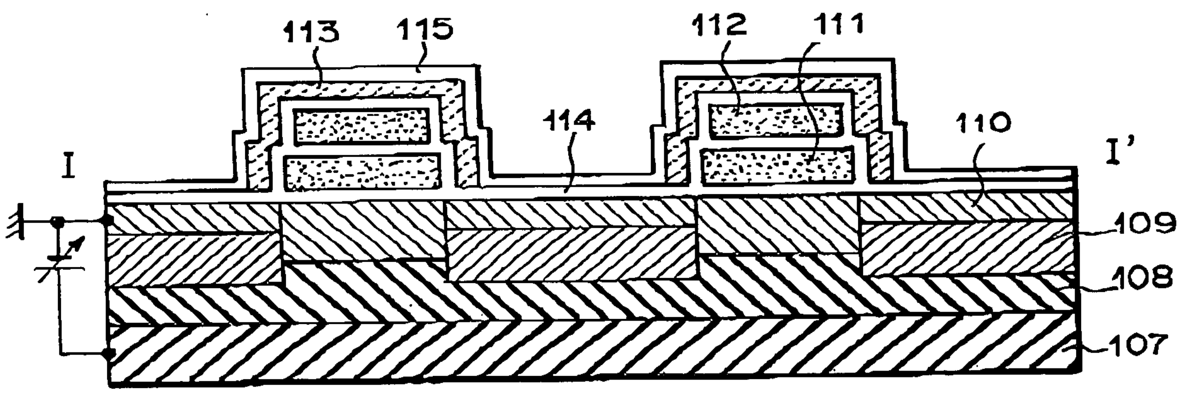


φ4
φ3
φ2
φ1
101
102
11
21
31
41
51
61
12
22
32
42
52
62
13
23
33
43
53
63
Vout
104
103

【Figure 7】

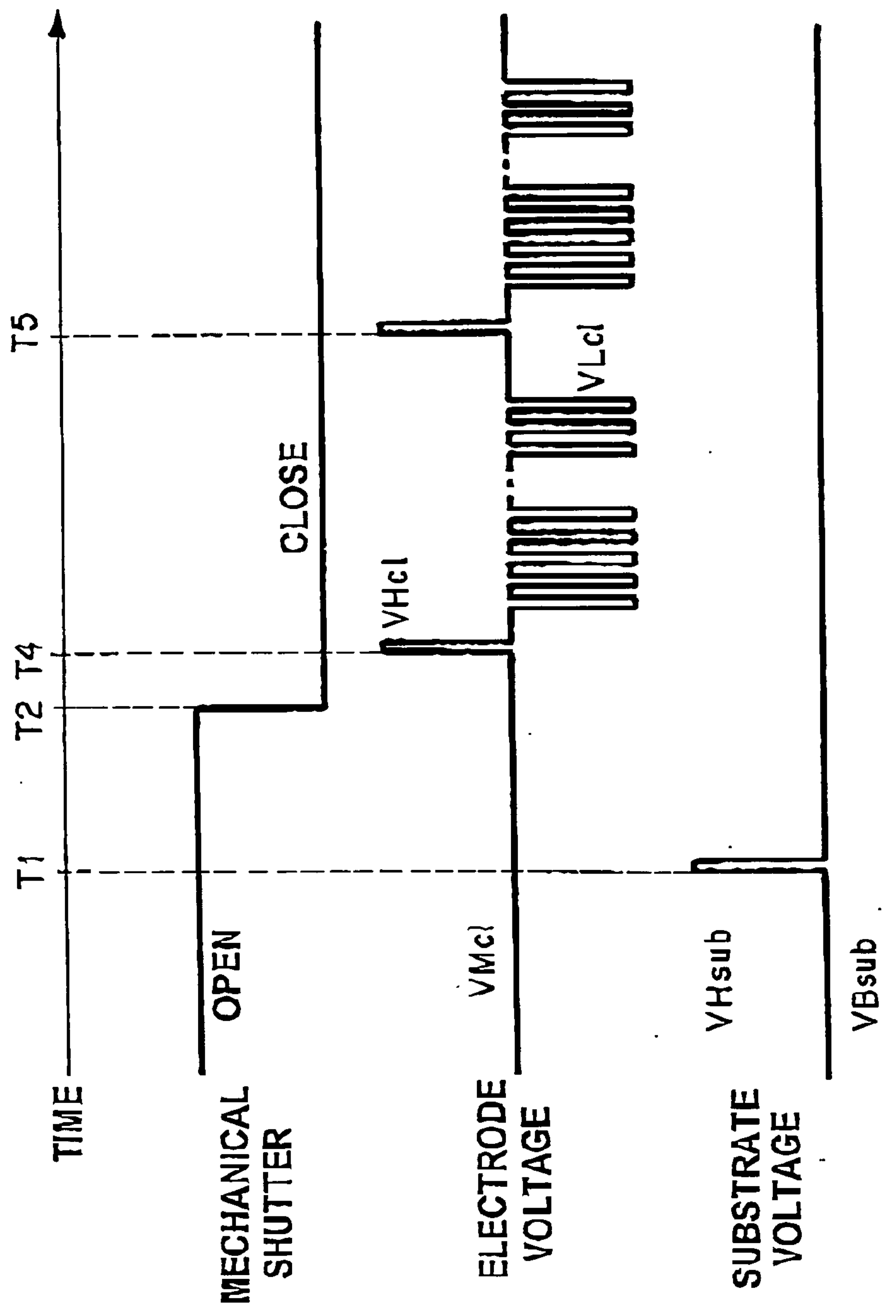


【Figure 8】



SUBSTRATE VPLTAGE Vsub

【Figure 9】



TIME
T1
T2
T4
T5
MECHANICAL SHUTTER
OPEN
CLOSE
ELECTRODE VOLTAGE
VMcl
VHcl
VLcl
SUBSTRATE VOLTAGE
VHsub
VBsub

【Figure 10】